Long-Term Index Site Monitoring Project: 2001 Data Summary

Clark County Public Works
Water Resources Section

Prepared for the

NPDES Stormwater Management Program

and the

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Table of contents

1.0 Background and Purpose

1.1 Project Background

The Long-Term Index Site Monitoring Project (LISP) is conducted by Clark County Public Works, Water Resources section (WR). The LISP is designed to satisfy requirements of the county's 1999 NPDES municipal stormwater permit conditions S5.B.4. and S9.C.5. to describe watershed conditions, evaluate overall program effectiveness, and assess the degree to which stormwater influences water bodies. The index site monitoring program is also intended to meet longer term needs under future permits to assess trends in water body health over time.

In addition to mandated NPDES requirements, the Board of Clark County Commissioners (BOCC) and the county's Clean Water Commission (CWC) have made clear statements requesting scientifically defensible information about water quality status and trends. Long-term monitoring will provide a basis for determining whether overall approaches for improving water body health are achieving measurable results.

Stormwater-influenced or dominated streams can act as an integrated indicator of human-caused changes to watershed health. There is little historical information describing the condition of these smaller, stormwater runoff-conveying streams in Clark County. Many of these streams have been impacted by human activities and exhibit water quality degradation, hydrologic changes, and habitat alterations, but few data exist to systematically document current conditions or trends in stream condition. The long-term monitoring project addresses this information gap by providing information describing trends in stream condition at a number of sites in the county.

A growing body of scientific literature (NMFS, August 1996; US EPA, July 1999; Center for Watershed Protection, 1998; and Idaho Department of Environmental Quality, 1999), recommends the use of "indicators" to monitor and track changes in stream condition. Indicators are measurable parameters, or groups of parameters, which describe stream quality. They fall into several major categories, including land use, water quality, hydrology, physical habitat, and biological parameters. This project utilizes selected indicators from each of these categories, with the intent of identifying long term trends at a set of index sites typical of Clark County waterbodies.

This report briefly describes the project scope and methods, presents data collected during the initial year of project implementation, and summarizes current condition of the index sites. It is intended as a preliminary summary which will be augmented with further data collection and analyses.

2.0 Goals and Objectives

The project includes sample collection and field measurements at selected sites, laboratory analysis of samples, database management, and data analyses. Summary reports are prepared annually and submitted to Ecology along with the county's annual NPDES report.

2.1 Goal

The primary goal of the LISP is to identify stream health trends in several stormwater-influenced and stormwater-dominated streams by monitoring a set of stream health indicators.

2.2 General Objectives

The objectives of the LISP are to:

- Collect data that are representative of actual stream conditions and comparable to data collected by other local and regional agencies
- Provide Clark County decision-makers with scientifically defensible information about long-term trends in receiving-water condition at selected sites
- Assess the level of beneficial use attainment at selected sites
- Periodically refine the set of stream health indicators based on the current state of monitoring science and the long-term usefulness of the data generated
- Attempt to discern relationships between various stream health indicators (e.g. between water quality parameters and benthic macroinvertebrate populations)

3.0 Methods

3.1 Quality Assurance/Quality Control

Quality assurance procedures for the project are outlined in the Clark County NPDES Long-Term Index Site Monitoring Project: QAPP. Quality control at North Creek Analytical Laboratories (NCA) was performed in accordance with the laboratory's Ecology-approved quality assurance manual. Formal Chain-of-Custody documentation was prepared for each sample set. Quality control at Aquatic Biology Associates, Inc. (ABA) was performed according to ABA's in-house quality assurance protocols and in accordance with the specifications of Ecology's benthic macroinvertebrate laboratory protocols.

3.2 Site Selection and sampling design

Long-term monitoring site locations were chosen based primarily on long-term accessibility. Secondary considerations included subwatershed geology, stream gradient, and drainage area land use, with the goal of distributing monitoring sites over a range of typical county streams. Using long-term accessibility as the primary selection criteria meant that in most cases sites were chosen on public lands where easements or other costly arrangements would not be required to ensure perpetual access.

Sites are located on lands owned by school districts, Vancouver/Clark Parks, Clark County Public Works, Washington Department of Natural Resources (DNR) and the City of Camas. One reach is located on private land adjacent to a county bridge. Access was secured through a Memorandum of Understanding (MOU) between Clark County and each land-owning entity. The necessity of selecting stream reaches of at least 40 stream widths in length (400 feet to 1100 feet) greatly limited the possible number of sites on public lands.

Figure 1 shows the location of the ten LISP sites. Specific locations of the index sites are listed below. Aerial photos of the sites and their drainage areas may be found in the Appendix. In some cases, the grab sampling location differs slightly from the location of habitat and benthic invertebrate surveys due to accessibility. The TRS coordinates specified here are for the grab sampling locations:

1) Breeze Creek at La Center Bottoms:	T4N, R1E, S3, NW
2) Chelatchie Creek at Hwy 503:	T5N, R3E, S16, SW
3) Cougar Creek at Columbia River H.S.:	T3N, R1E, S34, SW
4) Curtin Creek at 139th St:	T3N, R2E, S29
5) Gee Creek at Ridgefield H.S. and Royle Road:	T4N, R1E, S29, NW
6) Jones Creek above City of Camas water intake:	T2N, R4E, S3, SW
7) Matney Creek at 68th St:	T2N, R3E, S9, SE
8) Mill Creek at Salmon Creek Ave:	T3N, R1E, S24, NE
9) Rock Creek North at Gabriel Road:	T4N, R2E, S2, NE
10) Whipple Creek at NW 179th St:	T3N, R1E, S17, N

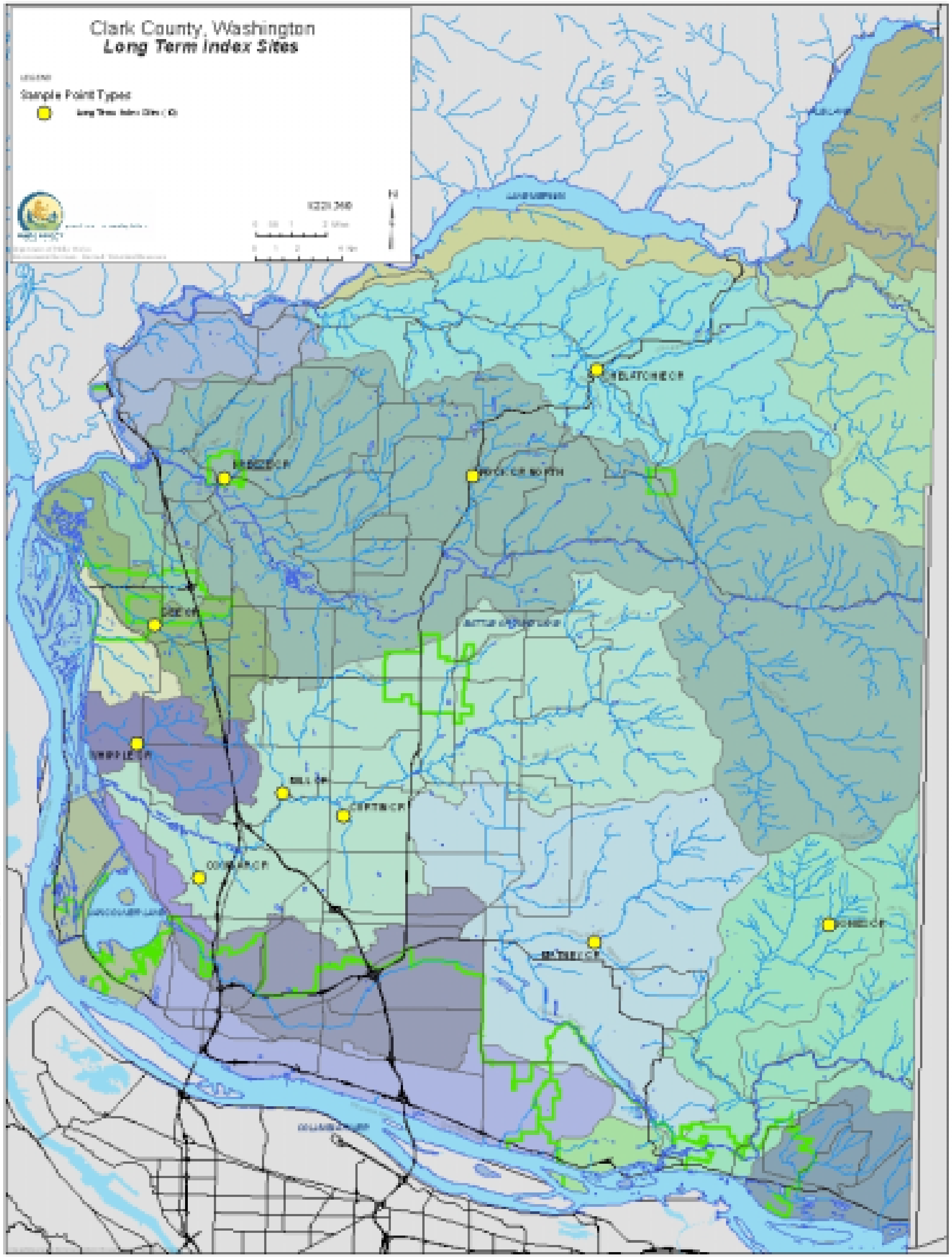

Figure 1. Location of the ten LISP monitoring sites, 2001.

3.3 Limitations of study design and data use

The site selection process was intended to choose a set of sites that could be tracked individually through time and, possibly, as a group to help make a qualified statement about stream health condition and trends in Clark County.

There are limitations in the way data from this project should be interpreted. Sites were selected based on ease of attaining long-term access, a sampling design referred to as "convenience sampling". Convenience sampling designs are often used when schedules, site availability, and resources preclude the use of more robust statistical sampling designs. The disadvantage of convenience sampling is the fact that results are difficult to compare between sites, and cannot be extrapolated to areas which are not sampled. The bias introduced by choosing sites based on convenience limits the use of the data on a statistical basis (Fore, 2001;EPA, 1999)

Therefore, information gained from this project is technically applicable only to the specific sites being monitored. In some cases, it may be possible to draw comparisons between the sampled sites. However, comparisons between sampled sites and extrapolations of results to unsampled areas are not advisable. Based on these conditions, there are certain questions which can and cannot be answered by this project:

Examples of answerable questions:
1) Is biological integrity increasing at the Mill Creek index site?
2) Does water temperature at the Cougar Creek index site meet state standards?
3) Are habitat conditions being degraded over time at the Breeze Creek index site?

Examples of questions that cannot be answered directly by this project:
1) Is Curtin Creek more healthy than Rock Creek?
2) What percentage of streams in Clark County meet water quality standards for bacteria?
3) Is Morgan Creek (an unsampled stream) significantly degraded from its natural condition?

Data from the index sites are primarily suitable for tracking long-term changes at the individual sites. However, these data may still be used in conjunction with other information to help build a county-wide "report card" of stream health. For instance, county subwatersheds can be grouped based on various relevant parameters such as average elevation, drainage area, total impervious area, or others. It may be possible to use data collected from index sites within a given set of subwatersheds to estimate potential conditions throughout that group.

3.4 Sampling Schedule

Monitoring activities began in late summer of 2001. Benthic macroinvertebrate samples were collected during September 2001 and habitat surveys were completed during August and September 2001. Monthly grab sampling for water quality parameters was initiated in October 2001 to coincide with the beginning of the 2002 water year.

Continuous temperature loggers were not deployed during the 2001 monitoring season. The initial deployment of temperature loggers will take place during the 2002 monitoring season. Hydrologic data gathering will also begin during 2002. Hydrologic data gathering during 2001 was generally limited to measurement of stage during monthly grab sampling events. Estimates of discharge were also collected during benthic macroinvertebrate monitoring events.

Stream health indicators, sampling schedules, and sample types for 2001 LISP monitoring activities are shown in Table 1.

Indicator (Group)	Schedule	Sample Type
Benthic macroinvertebrates	annual---September 2001	composite
Rapid Habitat Assessment	annual---September 2001	visual survey
(Quantitative Habitat)	annual---Aug-Sept 2001	quantitative survey
gradient		
canopy cover		
bank condition		
woody debris		
substrate composition		
Temperature	monthly---start October 2001	portable meter
Dissolved Oxygen	monthly---start October 2001	portable meter
Conductivity	monthly---start October 2001	portable meter
pH	monthly---start October 2001	portable meter
Turbidity	monthly---start October 2001	grab
Bacteria (enterococcus)	monthly---start October 2001	grab
(Hydrologic)	monthly---start October 2001	stage measurement

Table 1. 2001 Long-term Index Site Project parameters and schedule.

3.5 Field Procedures

3.5.1 General

Sampling, analysis, and data management procedures were conducted according to the guidelines established or referenced in the Clark County Long-term Index Site Monitoring Project QAPP and in the contracts between Clark County and the laboratory facilities. Hard copies of all field data sheets and laboratory analyses are stored at WR.

Sample containers for laboratory delivery were labeled in indelible ink with the following information:

Clark County
Long-term Index Project
Site Name
Monitored Constituent
Date
Time

Standardized field sheets were completed for all field activities in place of general log books. Field sheets were printed on waterproof paper and entries made with pencil or indelible ink. In addition to field measurements, field sheet entries included the following, as appropriate:

Project name and site
Identity of field personnel
Changes in plan
Antecedent conditions

Number of samples collected
Date and time
QC sample identification
Unusual circumstances affecting data interpretation

Records were cross-checked for consistency between labels, custody documents, field sheets, and other relevant data. Documentation is archived in WR files.

All equipment was inspected and maintained by trained WR staff. Instruments were calibrated according to manufacturer's instructions prior to each field visit or deployment.

3.5.2 Water Quality Indicators

Water quality samples were collected in properly preserved bottles prepared by the laboratory. Samples were stored on ice or in the refrigerator until delivery to NCA. Samples were picked up by laboratory personnel within 24 hours of collection. Formal Chain of Custody documents were prepared for all samples sent to NCA and are on file with WR.

Grab samples were collected from approximately mid-channel, by wading when possible, or with a long-handled dipper during high flows. When wading, samples were collected from upstream of the individual to avoid contaminating the sample with disturbed sediment.

Conductivity, pH, temperature, and dissolved oxygen measurements were collected at the time of grab sampling with a Hydrolab DataSonde 4® multi-parameter water quality instrument.

3.5.3 Biological Indicators

Benthic macroinvertebrate sampling was performed according to methods described in Ecology's *Benthic Macroinvertebrate Biological Monitoring Protocols for Rivers and Streams* (Plotnikoff, 2001 Revision*)*. However, the D-frame net utilized in our sampling was not equipped with a device to enclose a one-foot by two-foot area for sampling. A two square-foot area was estimated upstream of the net. Sampling was conducted by 2-3 person field crews.

In most cases, samples were collected from riffle substrates only. Pools and glides were not sampled, regardless of the percentage of each habitat type within the reach. However, in one case riffles were nonexistent (Curtin Creek) and samples were collected from the available substrate within the reach.

3.5.4 Physical Habitat Indicators

Qualitative habitat assessments were conducted using the EPAs *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Habitat and Physicochemical Parameters (1999).* Field sheets were modified slightly to clarify certain descriptions and interpretation. An example field sheet may be found in the Appendix. Assessments were conducted during mid-late summer by 2-3 person field crews.

Quantitative habitat assessments were conducted using portions of the University of Washington's *Physical Habitat Assessment Protocols for Puget Sound Lowland Streams (1994).* Measurements were collected for the following parameters:

gradient

canopy cover
channel cross-section
large woody debris
substrate composition

In some cases, less than the prescribed 11 transects were sampled due to the limited length of stream within the monitoring reach. An example field sheet is included in the Appendix.

3.5.5 Hydrologic indicators

Limited implementation of stage and discharge monitoring was planned for 2001. General groundwork was laid for the creation of discharge-rating curves and subsequent installation of continuous stage recording equipment. Specifically, staff scouted locations for flow gaging and created standardized measure-down marks for collecting stage measurements.

A separate project was created to begin stream gaging activities to construct discharge-rating curves at the ten index sites. These curves should be completed by early 2003.

3.5.6 Land-use indicators

Limited land-use indicator analysis was planned for 2001. Road densities (mi/mi^2)were calculated for the area draining to each index site as a coarse indicator of the level of human impact.

3.6 Laboratory Procedures

All water quality samples were transported to the lab by laboratory personnel within 24 hours after collection. Standard Chain of Custody procedures were followed.

All turbidity and bacteria analyses were conducted by NCA. All procedures were performed according to the laboratory's Ecology-approved quality assurance program and according to accepted conventions for data manipulation and reporting as described in Standard Methods (APHA, 1992). Table 2 shows the constituents measured, analytical methods, and reporting limits used during 2001.

Data were reported as digital Excel worksheet files and backed up with mailed hard copies.

Constituent	Units	EPA Method	Reporting Limit
Turbidity	NTU	180.1	0.2
Enterococcus	CFU	SM 9230 B	2.0 cfu/100ml

Table 2: Analytical methods for 2001 long-term index site monitoring project.

Benthic macroinvertebrate samples were preserved immediately after collection and shipped to ABA at the conclusion of the field season. Laboratory analyses were performed in accordance with Ecology-approved methods for standard taxonomic identifications and metric reporting. Results of taxonomic work were reported in digital Excel worksheet files and backed up with mailed hard copies. Analytical results forwarded to the county included overall taxonomic enumerations, metric compilations, and calculations for each site's B-IBI score.

3.7 Analytical Methods

Many of the indicator measurements utilized during 2001 result in a numerical index or score. For these indicators, no further calculations were necessary. Others require summing data from several transects or computing totals or average values.

Water quality parameters (turbidity and enterococcus) were analyzed by calculating index scores according to the procedures outlined in Ecology's Draft Washington Water Quality Index (WQI) (Hallock, 2001). Equations and rules for computation are included in the draft index documentation.

The WQI includes calculations for fecal coliform bacteria, but not for enterococcus. On the recommendation of Draft WQI author David Hallock, an adjustment was made to the fecal coliform equation to allow for calculation of an enterococcus index score.

The standard equation for the calculation of index scores in the WQI is as follows:

$\text{WQI} = a + b_1(\ln \text{constituent}) + b_2(\ln \text{constituent})^2$, where

"a" and "b" are constant coefficients derived from a plotted curve of index values. The coefficients are provided in the draft WQI. For fecal coliform bacteria, the WQI is scaled to yield an index score of 80 when the measured value of the constituent is equal to the Class A water quality criterion. (e.g., the Class A criteria is 100 cfu/100ml. A water sample with 100 cfu/100ml would therefore yield an index score of 80).

The equation was adjusted as follows:

The draft criteria for enterococcus in Washington is 108 cfu/100ml. Therefore, the equation must be adjusted so that a sample with 108 cfu yields an index score of 80. According to Mr. Hallock, this may be accomplished by adjusting the value of the "a" coefficient. Utilizing the coefficients provided in the draft WQI, the equation

$80 = a + (0.819955\ (\ln 108)) + (-1.28485\ (\ln 108)^2)$ was generated. Solving for "a", the adjusted coefficient value for "a" was determined to be 104.374.

Following this adjustment, index scores were calculated for enterococcus according to the procedures outlined in the Draft WQI.

4.0 Results and Discussion

The primary purpose of this section is to summarize data from the first year of monitoring. For the first several years of LISP implementation, the primary focus of data analyses and discussion will be the initial characterization of conditions at the index sites. As sufficient data are collected over a period of years, trend testing will begin to provide information about the direction of long-term health at these sites.

Characterization and future trend evaluation will be conducted with an eye toward the level of beneficial use attainment at each index site. However, it must be stressed that the initial characterizations in this report are based on only minimal data. “Expected” natural conditions at the ten index sites would vary somewhat due to underlying differences in geomorphology, gradient, and ecoregion. Graphics summarizing overall conditions at the ten sites do not take these differences into account. The categorization of certain indicators as “good” or “poor” at a given site may be somewhat misleading in light of future data collection and more rigorous analysis. Therefore, site characterizations in this report should be interpreted as a preliminary “best guess” only, not as hard scientific “fact”.

As discussed in section 3.3, the LISP study design precludes many direct comparisons between index sites. Results from 2001 monitoring are therefore presented and discussed on a site-specific basis. For each site, a summary graph is presented showing the generalized results for the following seven measured indicators: benthic macroinvertebrates (B-IBI), Rapid Habitat Assessment, road density, embeddedness, canopy cover, turbidity water quality index, and enterococcus bacteria water quality index.

Results for each indicator are generalized into one of four categories: “poor”, “poor-fair”, “fair-good” and “good-excellent”. The graphs are also color-coded for ease of interpretation: black/poor, red/poor-fair, yellow/fair-good, and green/good-excellent. Table 3 shows the category ranges used for each of the seven graphed indicators. Specific numerical results for each graphed indicator are included in the text for each site, and are also summarized in Table 4. Additional summaries of non-graphed indicators (e.g. substrate data) are also included in the text for each site as appropriate.

Aerial photographs of each site and its surrounding drainage area are compiled in the Appendix. Laboratory data for water quality indicators and benthic macroinvertebrates are on file with WR.

Indicator/Parameter	Poor (1)	Poor/Fair (2)	Fair/Good (3)	Good/Excellent (4)
B-IBI score	10-19	20-29	30-39	40-50
Road density (mi/mi2)	>12	8-12	4-8	<4
Rapid Habitat Assessment	0-50	51-100	101-150	151-200
Embededdness (mean %)	75-100	50-75	25-50	0-25
Canopy cover (mean %)	75-100	50-75	25-50	0-25
Turbidity (WA WQI score)	<40	40-60	60-80	>80
Enterococcus (WA WQI score)	<40	40-60	60-80	>80

Table 3. Generalized ranges of scores used in 2001 summary graphics for seven selected indicators/parameters.

Site	Benthic Score	RHA Score	Road miles/mi2	Embededdness (mean %)	Canopy cover (mean %)	WQI-Turbidity (avg of worst three mo.)	WQI - Entero (avg of worst three mo.)
BREEZE	38	108	7.0	43	88	68	44
CHELATCHIE	36	138	5.6	38	no data	89	58
COUGAR	26	89	18.6	93	88	85	39
CURTIN	24	97	12.7	63	88	87	75
GEE	20	100	7.1	51	63	63	39
JONES	46	163	2.0	11	88	100	100
MATNEY	34	105	7.3	38	no data	82	75
MILL	30	114	7.9	65	88	79	58
ROCK	32	121	6.8	42	88	80	53
WHIPPLE	22	96	9.0	88	63	73	51

red = estimated from RHA, no quantitative data

Table 4. Summary of scores for selected indicators at the ten index sites, 2001.

4.0.1 Ecoregions

Ecoregions denote areas of general similarity in ecosystems, and in the type and quality of environmental resources. The continental United States is divided into 98 Level III ecoregions (U.S EPA, 1996), which have been further divided into Level IV ecoregions. Ecoregion delineations are useful for the development and application of biological criteria and water quality standards, management goals for nonpoint source pollution, and integrated ecosystem management. The ten LISP sites in Clark County fall into the following ecoregion categories described by Omernik (1987) and Bailey et al (1994):

3a: **Willamette Valley ecoregion, Portland/Vancouver basin**. "Rolling prairies, deciduous/coniferous forests, and extensive wetlands characterized the pre-settlement landscape of the Willamette Valley ecoregion." This sub-region is composed of "…undulating terraces and floodplains with numerous wetlands, oxbow lakes, and ponds. Historically, prairie and oak woodland grew on better drained sites while wetlands, Oregon ash, and Douglas-fir occurred elsewhere in the fault block basin. Today, this ecoregion is dominated by urban and suburban development, pastures, and nurseries." Annual rainfall averages 37-50 inches.

3d: **Willamette Valley ecoregion, Valley Foothills**. "Rolling prairies, deciduous/coniferous forests, and extensive wetlands characterized the pre-settlement landscape of the Willamette Valley ecoregion." This sub-region is a "…transitional zone between the Willamette Valley, The Cascades, and the Coast Range ecoregions. It has less rainfall than adjacent, more mountainous ecoregions and, consequently, its potential natural vegetation is distinct. Oregon white oak and Douglas-fir were originally dominant but, today, rural residential development, woodland, pastureland, vineyards, tree farms, and orchards are common." Annual rainfall averages 40-60 inches.

4a: Cascades ecoregion, Western Cascades Lowlands and Valleys. The Cascade ecoregion is "...a mountainous ecoregion…affected by alpine glaciations. It is characterized by steep ridges and river valleys in the west…. Its moist, temperate climate supports and extensive and highly productive coniferous forest…" This sub-region is "characterized by a network of steep ridges and narrow valleys. Elevations are generally less than 3200 feet…. The wet, mild climate promotes lush forests that are dominated by Douglas-fir and western hemlock." Annual rainfall averages 60-90 inches.

4.1 Breeze Creek @ La Center Bottoms

The Breeze Creek subwatershed lies in ecoregions 3a and 3d, with a drainage area above the index site of approximately 3.3 mi^2. Current land cover in the drainage is comprised primarily of forest and pasture land, with a small area of urban development within the confines of the city of La Center and some rural residential development. Breeze Creek flows in a fairly deep, steep-sided canyon for much of its length. Upland areas are largely cleared or open, but the riparian area and valley walls are generally forested and undeveloped. Stormwater inputs to Breeze Creek above the index site are a combination of piped urban runoff in the lower watershed and roadside ditches in the middle and upper reaches.

The index site reach is located near the mouth of Breeze Creek, approximately 300 feet upstream of its confluence with the East Fork Lewis River. Stream gradient in the reach ranges between 1% and 4%, falling into the low gradient (<5%) category. The index reach exhibits pool-riffle morphology (Montgomery and Buffington, 1993) and the substrate is primarily gravel and cobble.

Figure 2 shows the generalized scores for seven indicators at the Breeze Creek index site. Actual values for the seven indicators were as follows:

Site	Benthic Score	RHA Score	Road miles/mi2	Embededdness (mean %)	Canopy cover (mean %)	WQI-Turbidity (avg of worst three mo.)	WQI - Entero (avg of worst three mo.)
BREEZE	38	108	7.0	43	88	68	44

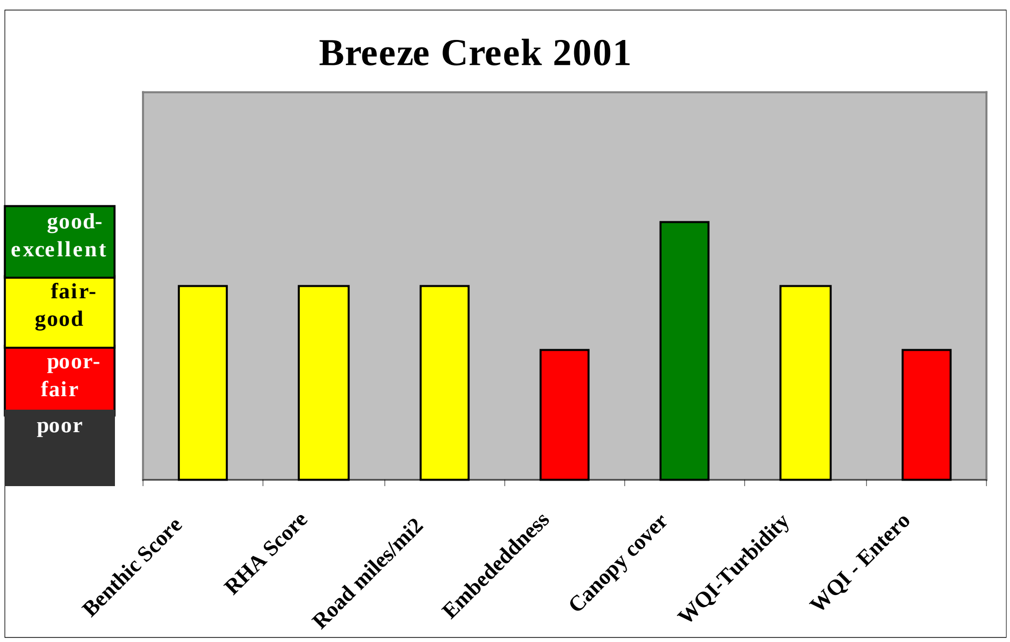

Figure 2. Generalized scores for selected indicators, Breeze Creek index site 2001.

The Large Woody Debris (LWD) tally for the Breeze Creek index reach indicated a density of approximately 50 pieces/km. Substrate data collected at the habitat transects indicated a substrate composition of approximately 3% bedrock, 0% boulder, 29% cobble, 41% gravel, 9% sand, 12% mud, and 6% wood debris.

Breeze Creek appeared to be moderately impacted by human activity. Only one indicator, canopy cover, scored in the good-excellent category. B-IBI, RHA, road density, and turbidity still fell into the fair-good range, but the embeddedness and bacteria indicators scored only poor-fair.

Stream banks were somewhat unstable and displayed high erosion potential and obvious undercutting, which suggests the flow regime in Breeze Creek has been impacted to some extent by upstream activities. Streambank vegetative protection was also marginal, with patches of bare soil and a moderate amount of non-native vegetation, especially in the lower end of the reach.

4.2 Chelatchie Creek @ SR 503

The Chelatchie Creek subwatershed drains approximately 12.5 mi^2 of land above the index site and lies entirely within ecoregion 4a. The headwaters lie in somewhat steeper areas, but for much of its length Chelatchie Creek runs through a fairly wide and generally flat valley floor. The drainage is sparsely populated, with dominant land cover of forest and agricultural/pasture lands. Stormwater inputs to Chelatchie Creek are essentially limited to roadside ditches.

The index site reach is located near the mouth, approximately 200 feet upstream of its confluence with Cedar Creek. Chelatchie Creek is a major tributary to Cedar Creek, which in turn has been identified as a salmon index stream by Washington Dept of Fish and Wildlife (WDFW). Stream gradient in the index reach is quite low, averaging <1% to perhaps 3%. The index reach is dominated by a series of beaver ponds in a fairly wide, wooded wetland area. Due to the depth and width of the beaver ponds, quantitative habitat measurements could not be collected. Reach morphology tends toward pool-riffle in the lowest areas not influenced by beaver dams, with gravel-cobble substrate.

Figure 3 shows the generalized scores for the Chelatchie Creek index site. Actual scores for these seven parameters were as follows:

Site	**Benthic Score**	**RHA Score**	**Road miles/mi2**	**Embededdness (mean %)**	**Canopy cover (mean %)**	**WQI-Turbidity** (avg of worst three mo.)	**WQI - Entero** (avg of worst three mo.)
CHELATCHIE	36	138	5.6	38	no data	89	58

Quantitative habitat parameters such as the Large Woody Debris (LWD) tally, substrate tally, and canopy cover were not measured for the Chelatchie Creek index site during 2001.

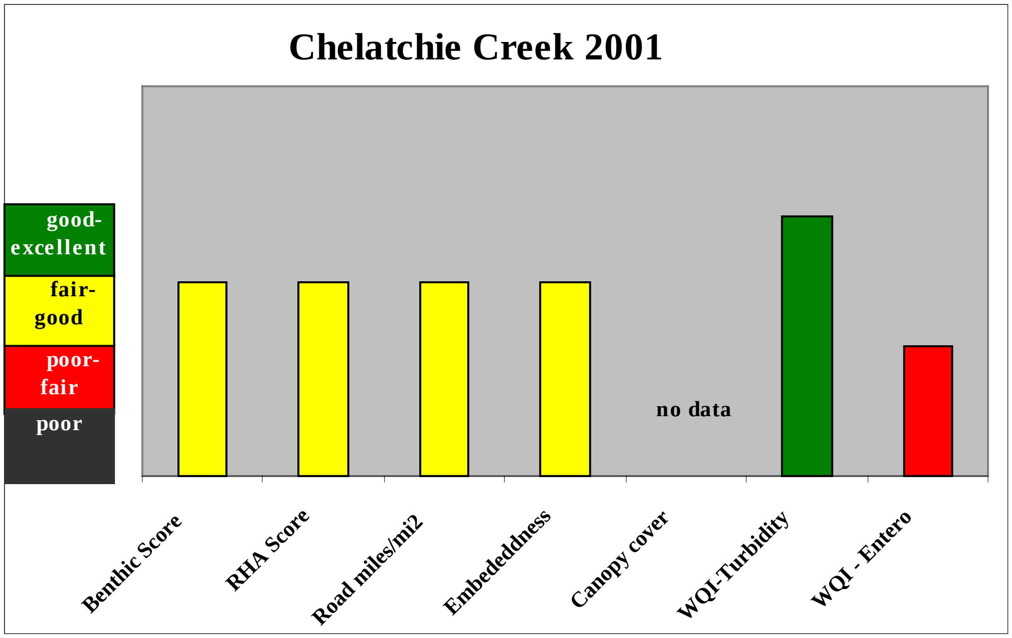

Figure 3. Generalized scores for selected indicators, Chelatchie Creek index site 2001.

Overall, the Chelatchie Creek site appeared to be slightly-moderately impacted by human activity. Turbidity was the sole indicator to score in the good-excellent range, while the remaining indicators fell into the fair-good category. The exception was the bacteria indicator, which scored poor-fair.

Banks were moderately stable, with little sign of significant erosion. Vegetative protection on streambanks was nearly optimal, with mostly native species in and around beaver ponds and non-native grasses near the bottom end of the reach.

4.3 Cougar Creek @ Columbia River H.S.

Cougar Creek lies entirely within ecoregion 3a. The Cougar Creek index site is located near the midpoint of the watershed, with a drainage area of approximately 2.1 mi^2. This is the most extensively urbanized subwatershed among the ten index sites, with land cover almost exclusively comprised of urban development. In the middle and lower sections, the creek runs in a narrow canyon with somewhat intact riparian areas. Toward the headwaters, the creek is mostly channelized or piped under urban development. Urban stormwater inputs to the creek are significant.

Stream gradient in the index reach averaging from <1% to approximately 3%. Reach morphology tends to be pool-riffle, with a sand-gravel substrate.

Figure 4 shows the generalized scores for the Cougar Creek index site. Actual scores for these seven parameters were as follows:

Site	Benthic Score	RHA Score	Road miles/mi2	Embededdness (mean %)	Canopy cover (mean %)	WQI-Turbidity (avg of worst three mo.)	WQI - Entero (avg of worst three mo.)
COUGAR	26	89	18.6	93	88	85	39

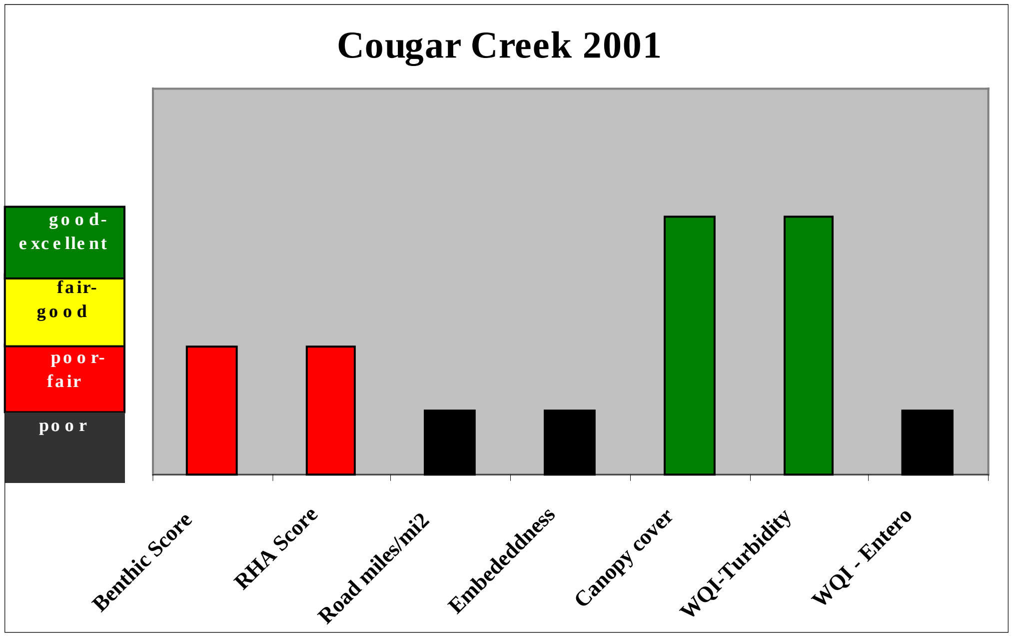

Figure 4. Generalized scores for selected indicators, Cougar Creek index site 2001.

The Large Woody Debris (LWD) tally for the Cougar Creek index reach indicated a density of approximately 132 pieces/km. Substrate data collected at the habitat transects indicated a substrate composition of approximately 2% bedrock, 0% boulder 6% cobble, 26% gravel, 42% sand, 13% mud, and 11% wood debris.

Overall, the Cougar Creek site appeared to be moderately to highly degraded. Though scoring in the good-excellent category for canopy cover and turbidity, the remaining indicators ranked in the poor-fair or poor categories. Biological integrity, as measured by the B-IBI, appeared to be significantly degraded, as was the overall habitat quality. embeddedness was very high, and bacteria samples scored in the poor category.

Banks were moderately unstable, with obvious erosional scars and actively eroding sections. Much of the streambank vegetation has been scoured away, leaving less than 50% of the streambank surface covered with vegetation, little of it composed of native species.

4.4 Curtin Creek @ 139th St

The Curtin Creek subwatershed lies in ecoregion 3a, with a drainage area above the index site of approximately 5.7 mi^2. Current land cover in the drainage is a mix of urban residential and open pasture or agricultural land. Most of the residential development is in the upper watershed and headwater region. There are remnants of large historical wetland areas in the headwaters and scattered throughout this fairly flat, low gradient watershed. Nearly all historical forest and wetland has been cleared or altered. Much of the channel (from approx. ½ mile upstream of the index site to the headwaters) is man-made. Urban stormwater inputs are present in the headwaters, while the middle and lower reaches are generally limited to roadside ditch inputs.

The index reach lies near the mouth of the watershed, approximately ¾ mile upstream of the confluence with Salmon Creek. Stream gradient is low through the index reach, less than 2%, and the reach morphology falls into the "regime" class. There appears to be significant groundwater input to Curtin Creek in and above the index reach, as evidenced by observed springs and temperature moderation throughout the year. The substrate is dominated by sand, with almost no gravel riffle habitat observed.

Figure 5 shows the generalized scores for the Curtin Creek index site. Actual scores for these seven parameters were as follows:

Site	Benthic Score	RHA Score	Road miles/mi2	Embededdness (mean %)	Canopy cover (mean %)	WQI-Turbidity (avg of worst three mo.)	WQI - Entero (avg of worst three mo.)
CURTIN	24	97	12.7	63	88	87	75

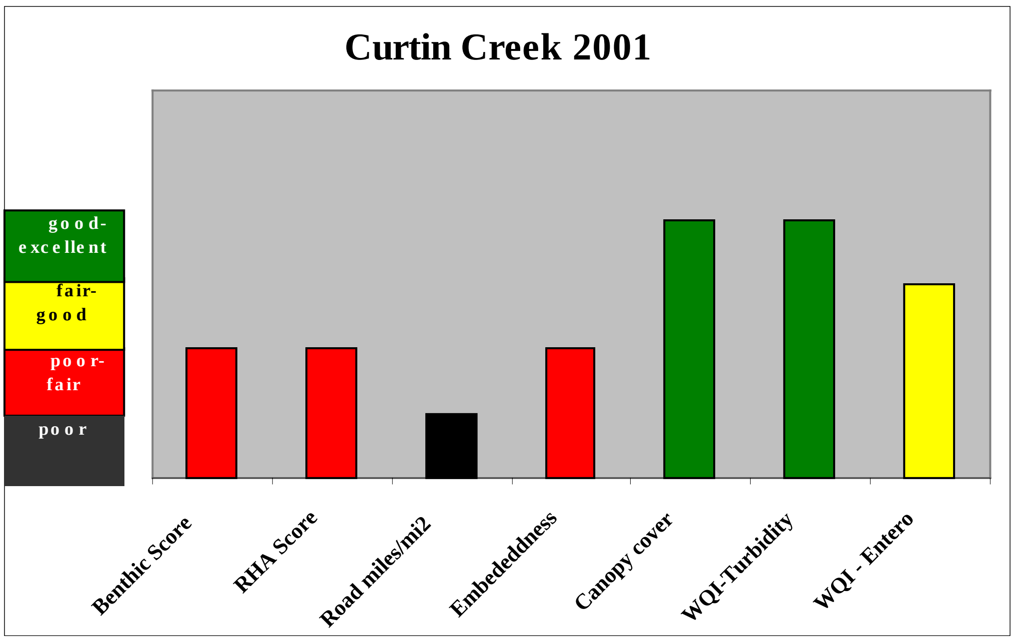

Figure 5. Generalized scores for selected indicators, Curtin Creek index site 2001.

The Large Woody Debris (LWD) tally for the Curtin Creek index reach indicated a density of approximately 33 pieces/km. Substrate data collected at the habitat transects indicated a substrate composition of approximately 0% bedrock, 0% boulder, 0% cobble, 2% gravel, 63% sand, 31% mud, and 0% wood debris.

The Curtin Creek index site appears to be slightly to moderately impacted. However, poor-fair scores for benthic invertebrates and embeddedness may be somewhat misleading, given the sand-dominated substrate in this area. The lack of any significant gravel and riffle areas likely lowered the B-IBI score, and the sand bottom probably artificially inflated the level of embeddedness. Canopy cover and turbidity scores were in the good-excellent category, while the bacteria indicator scored in the fair-good range. The sole indicator scoring in the poor category was road density. The LWD tally was the lowest of the measured index sites.

Banks were moderately unstable, with areas of erosion. Streambank vegetation was somewhat disrupted, with patches of bare soil in places.

4.5 Gee Creek @ Ridgefield H.S.

The Gee Creek watershed lies in ecoregion 3a, with a drainage area above the index site of approximately 9.5 mi^2. Land cover is dominated by open pastureland and rural residential development. Below the index reach, Gee Creek flows through the rapidly growing municipality of Ridgefield. In the middle and lower watershed, Gee Creek flows in somewhat steep-walled valleys with intact riparian forest. Nearer the headwaters and in the index reach, riparian zones are generally in pasture and there is a well-defined floodplain. Above the index reach, stormwater inputs tend to be from roadside ditches.

The index reach is located near the center of the watershed, in a relatively flat floodplain area with a gradient averaging 1-3%. Stream morphology is pool-riffle, with a gravel-sand substrate.

Figure 6 shows the generalized scores for the Gee Creek index site. Actual scores for these seven parameters were as follows:

Site	Benthic Score	RHA Score	Road miles/mi2	Embededdness (mean %)	Canopy cover (mean %)	WQI-Turbidity (avg of worst three mo.)	WQI - Entero (avg of worst three mo.)
GEE	20	100	7.1	51	63	63	39

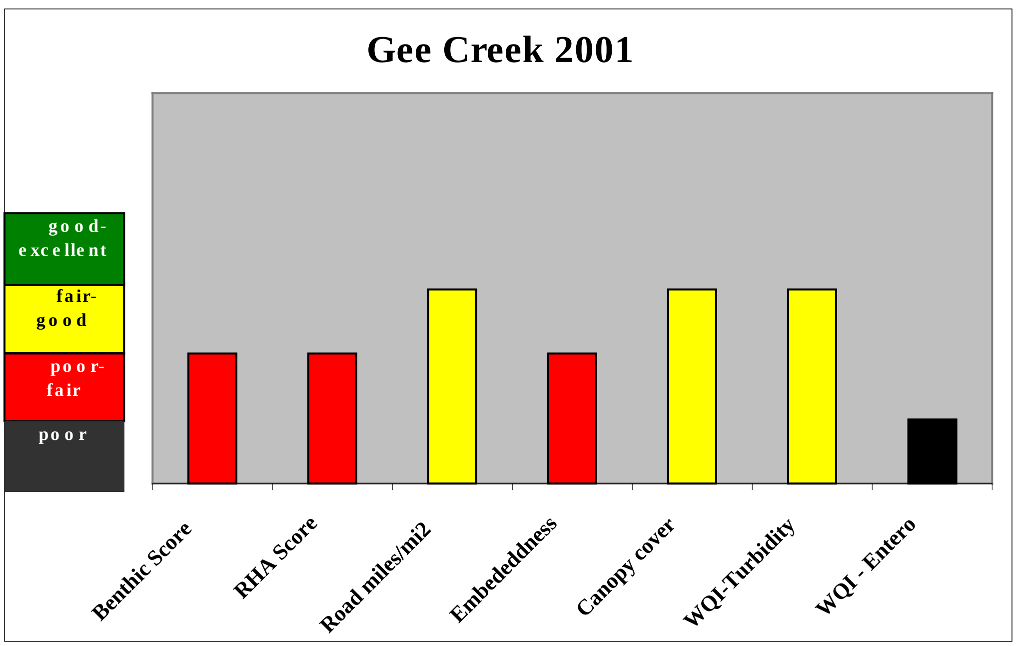

Figure 6. Generalized scores for selected indicators, Gee Creek index site 2001.

The Large Woody Debris (LWD) tally for the Gee Creek index reach indicated a density of approximately 127 pieces/km. Substrate data collected at the habitat transects indicated a substrate composition of approximately 0% bedrock, 0% boulder, 13% cobble, 42% gravel, 25% sand, 16% mud, and 3% wood debris.

The Gee Creek index reach appears to be moderately to highly degraded. No indicators scored in the good-excellent category. Road density, canopy cover, and turbidity scores were in the fair-good range, but the remaining indicators scored only fair-poor or, in the case of the bacteria indicator, in the poor category. Biological integrity, as measured by the B-IBI, was quite low despite a gravel-dominated substrate and pool-riffle morphology. Embeddedness was significant and likely impacted the benthic community.

Streambanks were moderately unstable, with evidence of past incision and some current erosional scarring. Streambanks vegetation was marginal, with a high percentage of non-native grasses, although instream cover was fairly good with the fourth highest tally of LWD among the eight index reaches where LWD was tallied.

Gee Creek was impacted in 2002 by a significant manure spill from a dairy operation upstream from the index reach. It is unknown to what extent the spill affected indicator scores.

4.6 Jones Creek above Camas water intake

Jones Creek lies in ecoregion 4a, with a drainage area above the index site of approximately 2.1 mi^2. Current land cover is entirely forest. A single logging road traverses a ridge along the headwaters, but no forestry activities have occurred for many years. Downstream from the index reach, water from Jones Creek is piped to the City of Camas as a potable water source.

The index site is located midway through the watershed, immediately upstream from the Camas water intake facility. Stream gradient in the index reach is fairly steep, averaging 3% to 5%. Morphology tends to fall into the pool-riffle and step-pool categories, and the substrate is co-dominated by boulder, cobble, and gravel.

Figure 7 shows the generalized scores for the Jones Creek index site. Actual scores for these seven parameters were as follows:

Site	Benthic Score	RHA Score	Road miles/mi2	Embededdness (mean %)	Canopy cover (mean %)	WQI-Turbidity (avg of worst three mo.)	WQI - Entero (avg of worst three mo.)
JONES	46	163	2.0	11	88	100	100

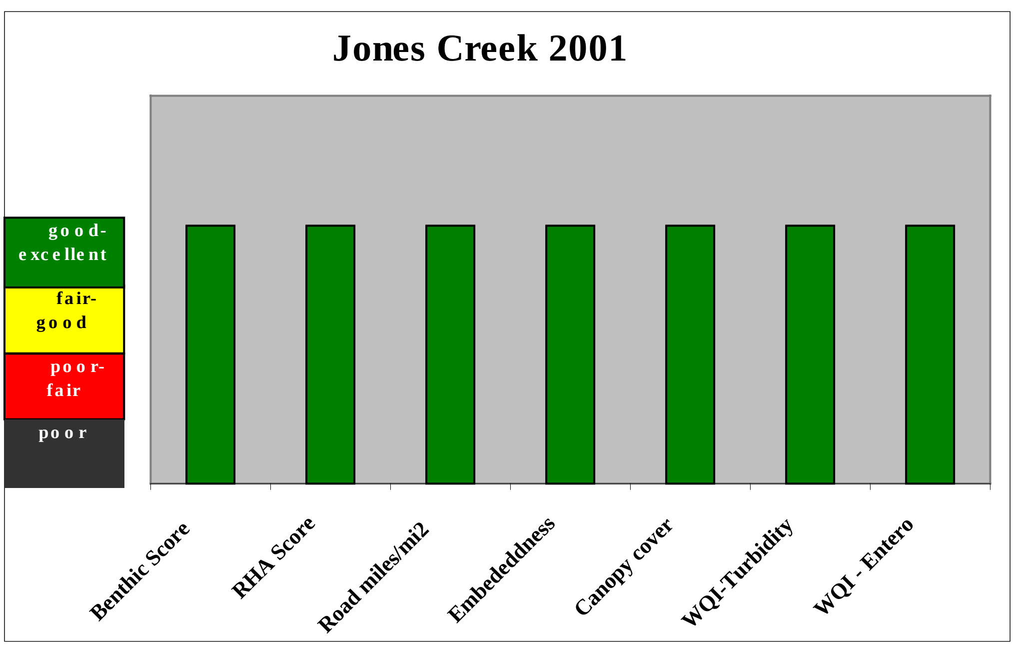

Figure 7. Generalized scores for selected indicators, Jones Creek index site 2001.

The Large Woody Debris (LWD) tally for the Jones Creek index reach indicated a density of approximately 95 pieces/km. Substrate data collected at the habitat transects indicated a substrate composition of approximately 0% bedrock, 33% boulder, 28% cobble, 32% gravel, 1% sand, 1% mud, and 4% wood debris.

Overall the Jones Creek index appeared to be unimpacted-slightly impacted. All seven of the graphed indicators scored in the good-excellent range. Streambanks were stable, with little evidence of recent erosion. Some channel widening and old erosional scars were observed. Streambank vegetative cover was consistently healthy and composed primarily of native species. The LWD tally was fairly low, indicating only limited recruitment of large wood.

4.7 Matney Creek @ 68th St

The headwater reaches of Matney Creek lie within ecoregion 4a, while the lower reaches fall into ecoregion 3d. The drainage area above the index site covers approximately 6.7 mi^2. Current land cover in the drainage is a mix of forest, rural residential, and open pasture land. Riparian forest is somewhat intact in the upper and lower reaches, while open pasture dominates the riparian zone in the middle reaches. Rural residential development is rapidly expanding in the remaining forested areas. The upper reaches are fairly steep, while the middle and lower reaches meander through fairly flat terrain.

The index reach is near the mouth of Matney Creek, a few hundred feet from the confluence with Lacamas Creek. Stream gradient in the reach is fairly low, averaging approximately 3%. The morphology tends to be pool-riffle, with a substrate dominated by gravel-cobble.

Figure 8 shows the generalized scores for the Matney Creek index site. Actual scores for these seven parameters were as follows:

Site	Benthic Score	RHA Score	Road miles/mi2	Embededdness (mean %)	Canopy cover (mean %)	WQI-Turbidity (avg of worst three mo.)	WQI - Entero (avg of worst three mo.)
MATNEY	34	105	7.3	38	no data	82	75

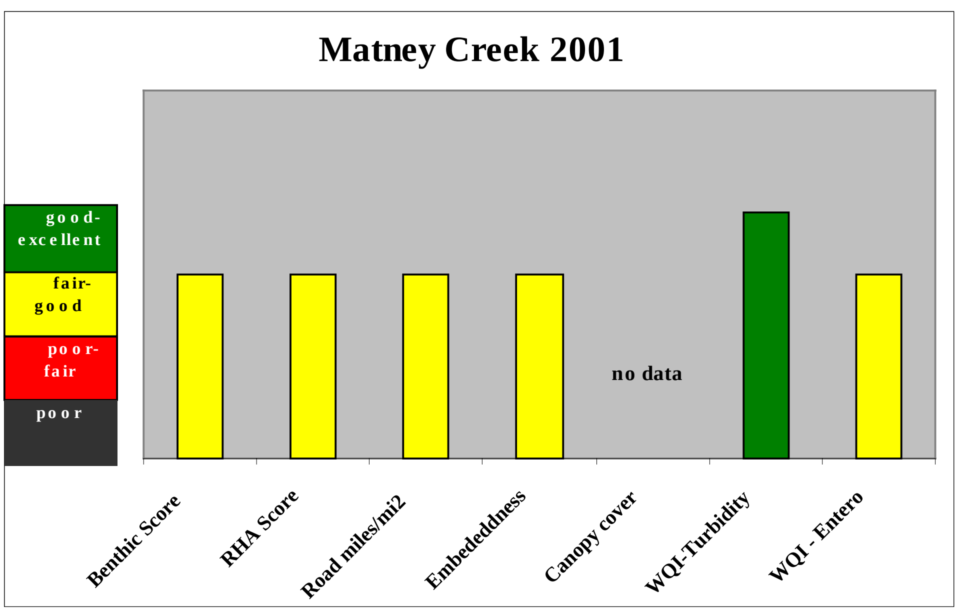

Figure 8. Generalized scores for selected indicators, Matney Creek index site 2001.

Quantitative habitat parameters such as the Large Woody Debris (LWD) tally, substrate tally, and canopy cover were not measured for the Matney Creek index site during 2001.

Overall, the Matney Creek index site appeared to be slightly degraded. The turbidity score ranked in the good-excellent range, while the remaining graphed indicators all fell into the fair-good category. No data were collected for canopy cover, but a visual estimate of canopy indicated that the reach was mostly shaded. Banks were moderately unstable, with evidence of recent erosion and incision. Streambank vegetation was degraded, with a significant amount of bank scour and a high percentage of non-native species.

It should be noted that three additional sites along the mainstem of Matney Creek were evaluated for RHA and benthic macroinvertebrates in a separate project during 2001. B-IBI scores for the additional sites ranged from 22 to 42 (out of a possible 50). RHA scores ranged from 76 to 133 (out of a possible 200). The range of conditions at these sites underscores the limitations in attempting to characterize an entire subwatershed based on a single index reach. Conditions vary widely even within a fairly small subwatershed like Matney Creek.

4.8 Mill Creek @ Washington State University

The Mill Creek subwatershed lies in ecoregion 3a, and has a drainage area of approximately 11.6 mi^2 above the index site. Land cover is dominated by pasture land and rural residential development. Urban residential and commercial development are increasing in the headwater region due to rapid growth in the city of Battleground. Most historical forests and wetlands have been removed or altered, and riparian zones are primarily in open pasture except toward the lower end of the watershed where some forested riparian areas remain and the creek enters a shallow canyon.

The index reach is located near the mouth of the Mill Creek, approximately ¼ mile upstream from its confluence with Salmon Creek. Stream gradient averages 1% to 3%, and the channel exhibits pool-riffle morphology. The dominant substrate is gravel-cobble.

Figure 9 shows the generalized scores for the Mill Creek index site. Actual scores for these seven parameters were as follows:

Site	Benthic Score	RHA Score	Road miles/mi2	Embededdness (mean %)	Canopy cover (mean %)	WQI-Turbidity (avg of worst three mo.)	WQI - Entero (avg of worst three mo.)
MILL	30	114	7.9	65	88	79	58

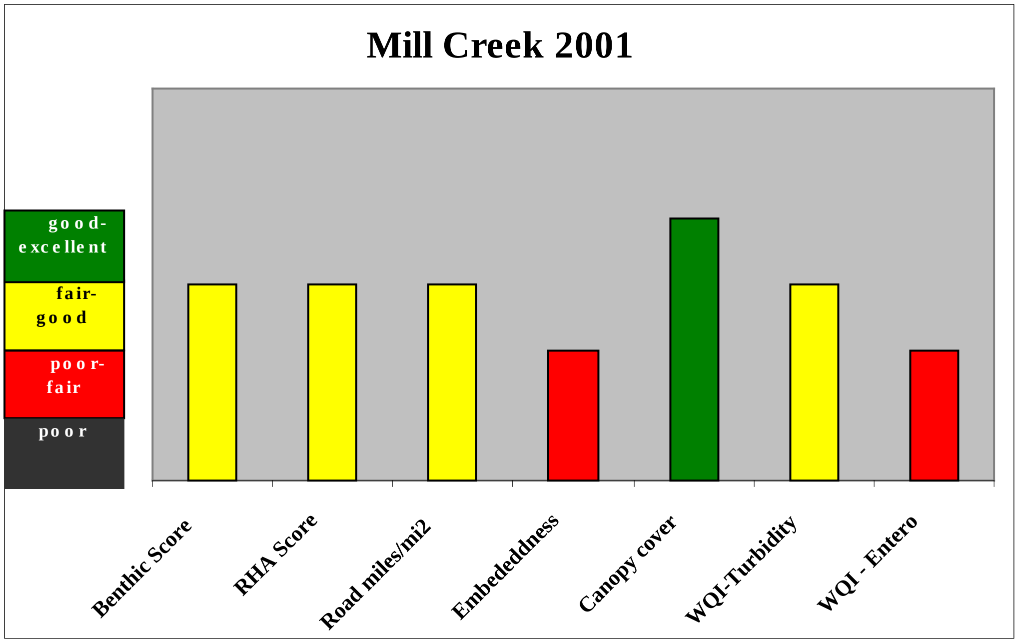

Figure 9. Generalized scores for selected indicators, Mill Creek index site 2001.

The Large Woody Debris (LWD) tally for the Mill Creek index reach indicated a density of approximately 145 pieces/km. Substrate data collected at the habitat transects indicated a substrate composition of approximately 7% bedrock, 0% boulder, 18% cobble, 31% gravel, 16% sand, 26% mud, and 1% wood debris.

The Mill Creek index reach appeared to be moderately degraded. While most graphed indicators scored in the fair-good category, only canopy cover was good-excellent and scores for embeddedness and bacteria were in the poor-fair range. Banks were moderately stable, but evidence of erosion from high flows was present. Streambank vegetation was disrupted, with bank scouring in many places and a high occurrence of non-native species.

The frequency of LWD was higher in this reach than in any other index reach in 2001, though still less than the desired amount. The higher occurrence of LWD in this reach likely was due, at least in part, to the placement of LWD during various stream rehabilitation projects.

4.9 Rock Creek North @ DNR land above Gabriel Road

The Rock Creek North subwatershed straddles ecoregions 3d and 4a, but the entire 6.5 mi^2 drainage area above the index site falls within ecoregion 4a. Land cover in the subwatershed is a mix of forest (with active logging), commercial agriculture, and rural residential development. Aside from a large, channelized and drained agricultural operation near Fargher Lake, much of the riparian zone forest remains intact. There are remaining areas of headwater wetlands, but much of the headwater areas are a mix of forest, agriculture, and increasing rural residential development.

The index reach is located midway through the watershed. Stream gradient in the index reach averages 2-3%, with pool-riffle morphology and a substrate composition dominated by gravel and cobble.

Figure 10 shows the generalized scores for the Rock Creek North index site. Actual scores for these seven parameters were as follows:

Site	Benthic Score	RHA Score	Road miles/mi2	Embededdness (mean %)	Canopy cover (mean %)	WQI-Turbidity (avg of worst three mo.)	WQI - Entero (avg of worst three mo.)
ROCK	32	121	6.8	42	88	80	53

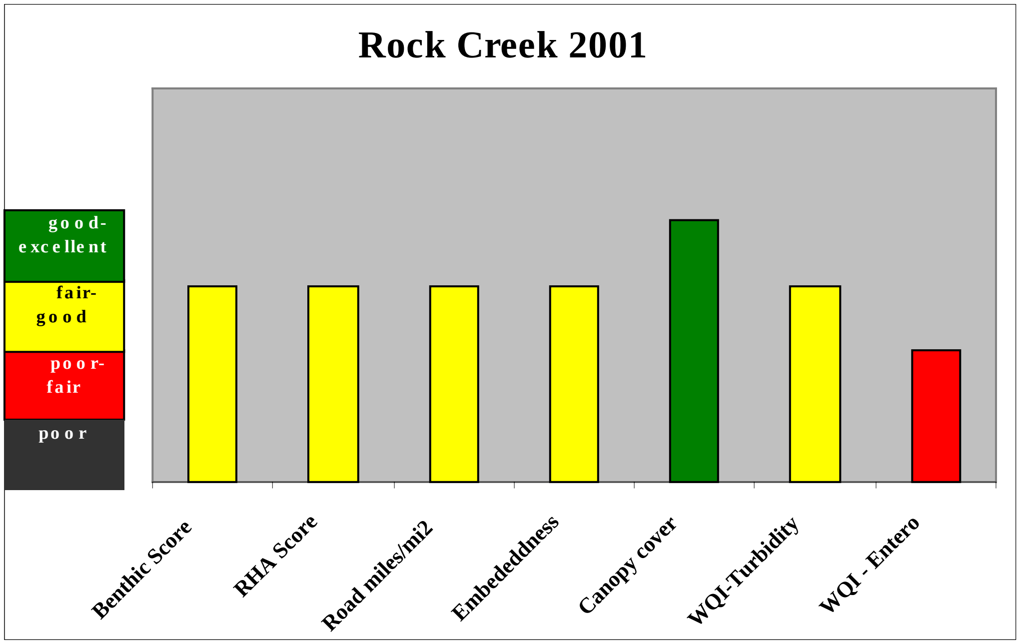

Figure 10. Generalized scores for selected indicators, Rock Creek North index site 2001.

The Large Woody Debris (LWD) tally for the Rock Creek North index reach indicated a density of approximately 144 pieces/km. Substrate data collected at the habitat transects indicated a substrate composition of approximately 0% bedrock, 2% boulder, 29% cobble, 38% gravel, 4% sand, 22% mud, and 5% wood debris. Rock Creek is the only index site where staff observed salmonid species during 2001 field work. Three to five live Coho salmon and several carcasses were observed within the index reach.

Overall, the Rock Creek index site appeared to be slightly to moderately impacted. Canopy cover scored in the good-excellent range, while the bacteria indicator ranked in the poor-fair category. The remaining graphed indicators were in the fair-good category. Banks were relatively unstable, with considerable erosion. Streambank vegetation was largely intact and comprised of mostly native species. The LWD tally for this reach was the second highest of the measured sites, though still less than the desired amount.

4.10 Whipple Creek @ 179th St

The Whipple Creek watershed lies in ecoregion 3a, and has a drainage area of approximately 8.2 mi^2 above the index site. Current landcover in the index site drainage area is dominated by urban density residential development in the headwaters, open pastureland with rural residential development in the middle reaches, and a small amount of intact forest cover in the lower reaches. For much of its length, Whipple Creek runs in fairly narrow, steep canyons. Riparian forest cover is fairly intact in many of these areas.

The index site is located midway through the watershed. Stream gradient is quite low in the index reach, averaging approximately 1%. The morphology is pool-riffle, with a gravel-dominated substrate.

Figure 11 shows the generalized scores for the Whipple Creek index site. Actual scores for these seven parameters were as follows:

Site	Benthic Score	RHA Score	Road miles/mi2	Embededdness (mean %)	Canopy cover (mean %)	WQI-Turbidity (avg of worst three mo.)	WQI - Entero (avg of worst three mo.)
WHIPPLE	22	96	9.0	88	63	73	51

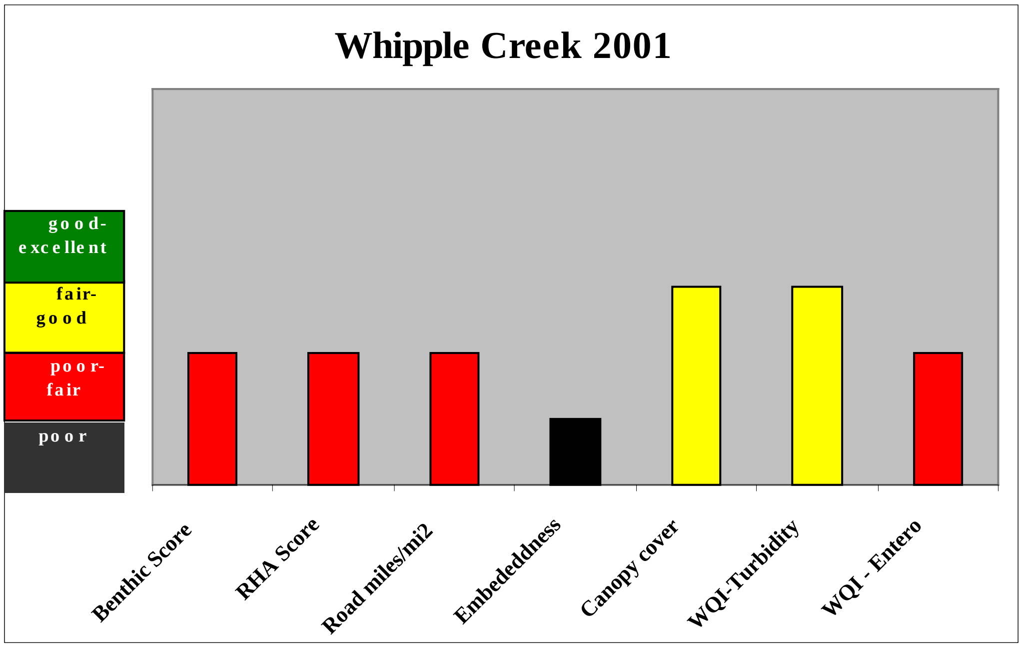

Figure 11. Generalized scores for selected indicators, Whipple Creek index site 2001.

The Large Woody Debris (LWD) tally for the Whipple Creek index reach indicated a density of approximately 44 pieces/km. Substrate data collected at the habitat transects indicated a substrate composition of approximately 0% bedrock, 0% boulder, 0% cobble, 46% gravel, 10% sand, 44% mud, and 0% wood debris.

The Whipple Creek index reach appeared to be moderately to highly impacted. Only the canopy cover and turbidity scores reached the fair-good category. Embeddedness fell into the poor category, while the remaining graphed indicators were in the poor-fair range. Banks were unstable, with many currently eroding areas and significant evidence of historical incision. Streambank understory vegetation was composed almost entirely of non-native species, with a significant amount of bank scour and exposed soil. The LWD tally was the second lowest of the measured index sites.

4.11 Examples of Range of Conditions

Figures 12, 13, and 14 are included as examples of the range of scores at the ten index sites in 2001. They are not intended as direct comparisons between sites. Rather, they depict the wide variation in scores and conditions encountered in Clark County streams. Only B-IBI, Rapid

Habitat Assessment, and road density are shown here. Similar variation occurred in nearly all measured indicators.

As noted in section 4.5, three mainstem Matney Creek sites in addition to the index reach were evaluated for RHA and benthic macroinvertebrates during monitoring projects in 2001. B-IBI scores at the four sites ranged from 22 (poor-fair) to 42 (good-excellent). RHA scores ranged from 76 (poor-fair) to 133 (fair-good). This variability in conditions underscores the difficulty in attempting to characterize an entire subwatershed based on a single index reach. Conditions vary widely even within a fairly small subwatershed like Matney Creek.

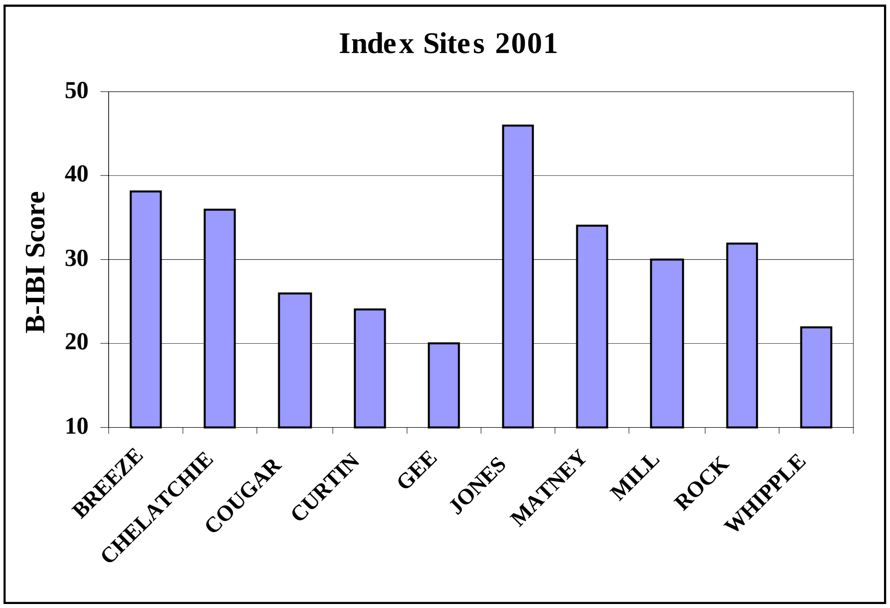

Figure 12. Range of B-IBI scores, LISP sites, 2001.

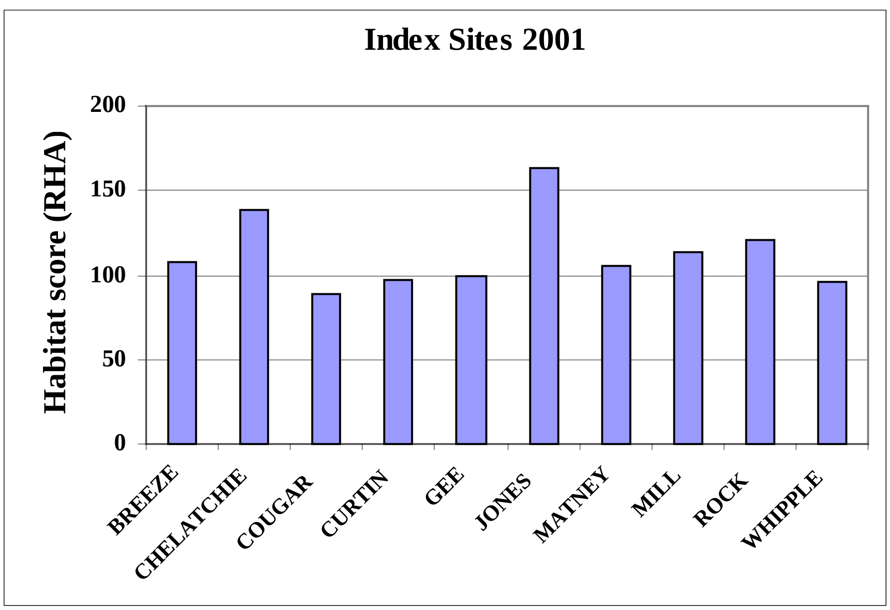

Figure 13. Range of Rapid Habitat Assessment scores, LISP sites, 2001.

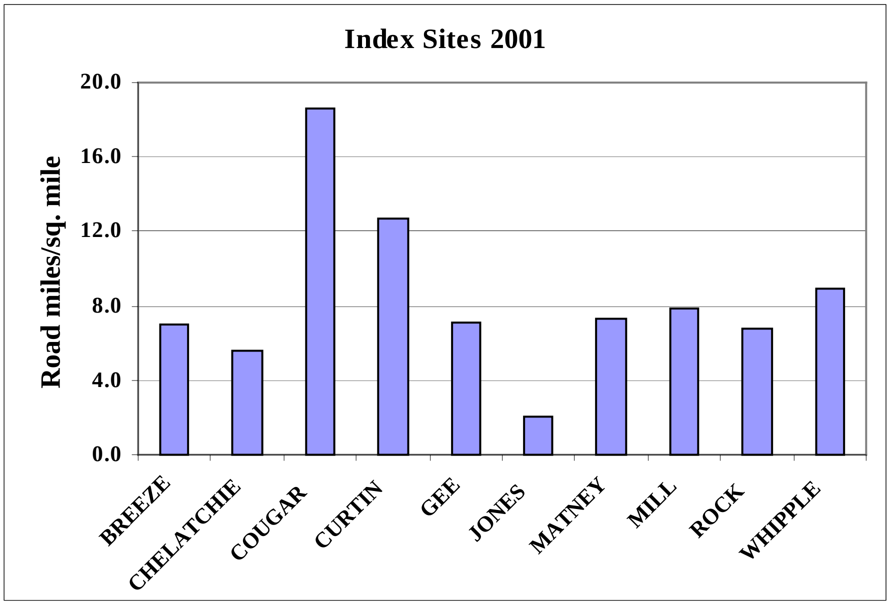

Figure 14. Range of road density, LISP sites, 2001.

5.0 Conclusion

This brief evaluation of 2001 LISP (first-year) results suggests that a wide range of stream health conditions exist within Clark County. Future monitoring and more extensive data analyses will be necessary to more fully characterize current conditions and track long-term trends in water body health at these sites. Attempts to characterize stream health as a whole in Clark County, or even in entire subwatersheds, will also require additional information.

Based on the current level of data, nine of the ten index sites show at least some signs of degradation due to human activities. Preliminary interpretations suggest that one index site was nearly unimpacted, while three appeared to be moderately-highly degraded. The remaining six sites ranged from slightly to moderately impacted.

6.0 Modifications for 2002

6.1 Oregon Water Quality Index

Beginning in May 2002, additional water quality parameters will be added to the monitoring project to allow calculation of the Oregon Water Quality Index (OWQI). Additions will include testing for ammonia, total phosphorus, and total solids.

Also beginning in May 2002, bacteria sampling will include both fecal coliform and e.coli bacteria. Concurrent sampling of both indicators for approximately one year will facilitate a full switch to e.coli bacteria by early 2003 in light of proposed changes to the state water quality criteria.

6.2 Changes to habitat protocol

As of May 2002, habitat protocols used for the LISP are being evaluated. It is likely that modifications or additions will occur prior to year 2002 monitoring. Possible modifications include the addition of thalweg profile measurements and performing a Wolmann pebble count.

6.3 Stream flow gaging

Discharge data are being collected under a separate project for the creation of discharge rating curves at the ten LISP sites. Beginning in January 2002, stage measurements are collected at the time of each grab sampling event. Stage measurements will be used to calculate stream discharge on each sampling date once the discharge curves are generated.

6.4 Update of benthic methods

Benthic macroinvertebrate monitoring methods may be adjusted to more fully utilize the Ecology protocol which was approximated in 2001. Possible changes include the addition of pool samples in streams with suspected degradation, and the addition of a 2 ft^2 grid attachment to the existing D-frame net to facilitate consistent areal sampling.

6.5 Change location of Cougar Creek site to 119^{th} St

Beginning in June, 2002, Clark County anticipates taking over responsibility for collecting grab samples at eight Clark Public Utilities (CPU) monitoring sites in the Salmon Creek watershed. This will eliminate some overlap in monitoring sites between CC and CPU. One of the CPU sites is located on Cougar Creek at 119^{th} St, approximately 1 mile downstream from the county's index site at 99^{th} St. To minimize overlap and take advantage of the longer period of record at the CPU site, the county will discontinue the 99^{th} St index site and move all index monitoring activities on Cougar Creek to the 119^{th} St site.

6.6 Change contributing drainage area for Curtin Creek

Further review of current maps indicated that the drainage area to the Curtin Creek index site in 2001 was not accurately depicted. During 2002, the map will be modified to show the entire drainage area. This will impact the road density calculations and subwatershed acreage in 2002.

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Appendix